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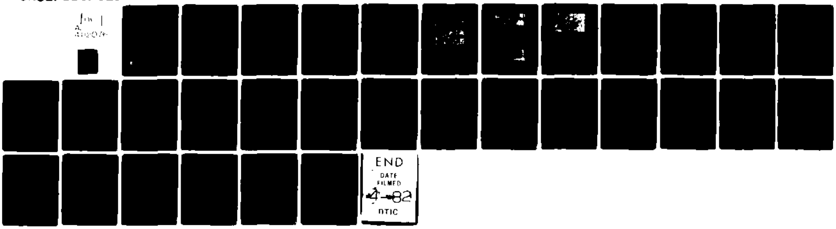

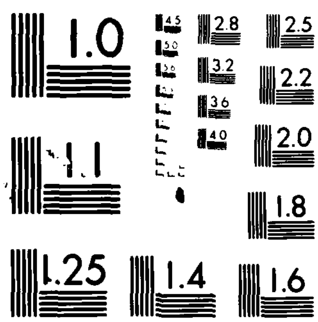

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A CASE OF OCCURRENCE OF LOW-TROPOSPHERE JET STREAMS AT THE EARTH'S SURFACE IN THE WEST CARPATHIANS

by

Elzbieta Budziszewska, Maria Morawska-Horawska

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A CASE OF OCCURRENCE OF LOW-TROPOSPHERE JET STREAMS AT THE EARTH'S SURFACE IN THE WEST CARPATHIANS

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1. Strong winds in Carpathians are not rare phenomena. Year after year their action causes large or small damage, among them damage to timbered areas. But the damage that was caused by winds in the Tatras, at Podhale and in West Beskids (Figure 1) in the evening on 6 May 1968 was exceptionally large. According to preliminary calculations, the total volume of timber destroyed in this case was about 360,000 m^3, out of which the loss suffered by the Tatra National Park was about 150,000 m^3. On the Slovak side the losses, according to press reports, reached about 100,000 m^3. The timbered areas, which suffered destruction on the Polish side by these unusually strong winds, are shown on the enclosed map (Figure 2).

An inspection carried out in the field shows that air streams which caused this catastrophe were flowing mostly in the valleys and on Northwestern slopes (Photograph 1). In the area of Tatra National Park we can distinguish four groupings of damages, namely:

a)slopes of DolinaMietusa and Dolina Malej Laki,
b) slopes of Hala Kondratowa and Dolina B[illegible]
c) slopes of Dolina Suchej Wody, and
d) Dolina Filipczanskiego Potoku, Wierch Poroniec and Dolina Poronca.

In addition to the above mentioned areas, smaller groupings of timber destruction are scattered in Dolina Rybiego Potoku, in Dolina Bialki and at Legy. They occur also at Podhale in the region

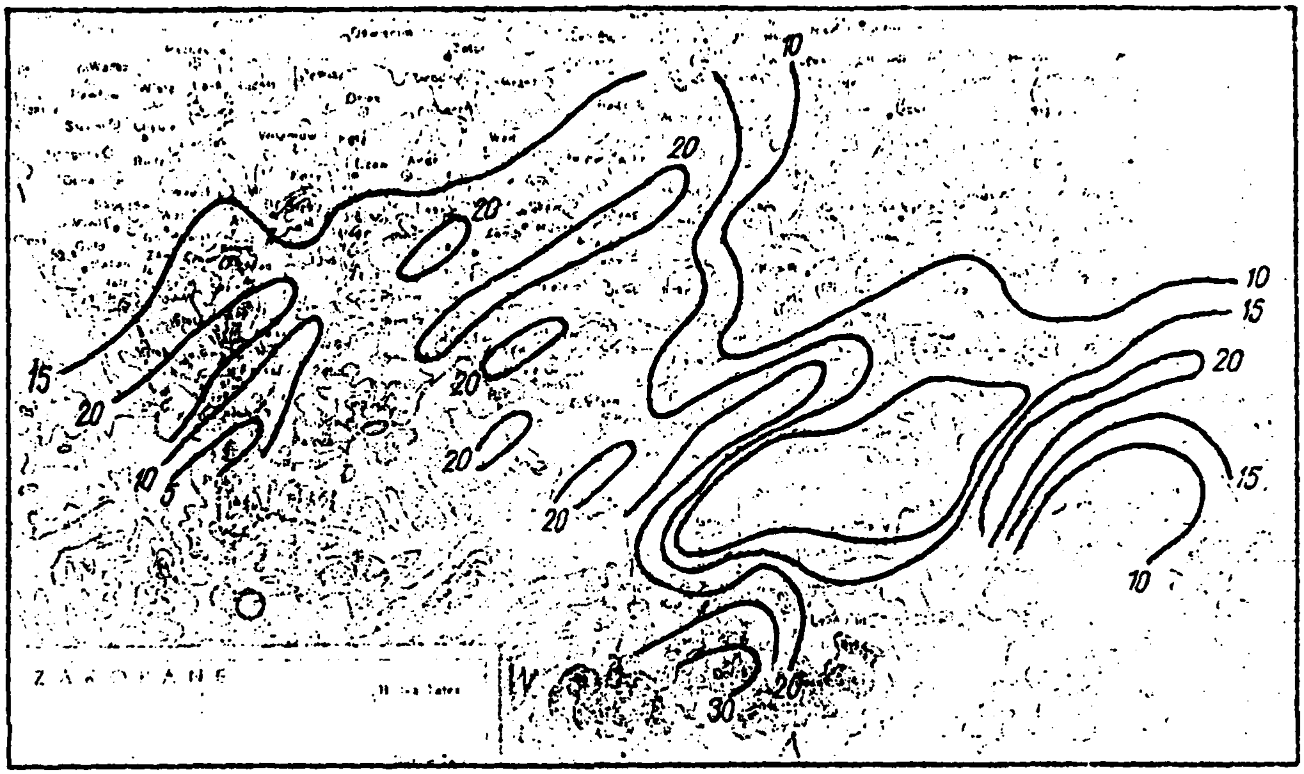

Fig. 1. Distribution of wind velocities in the area of Beskids and Tatras on 6 May 1968 at 19:40 hrs GMT. Isotachs are drawn every 5 m/sec.

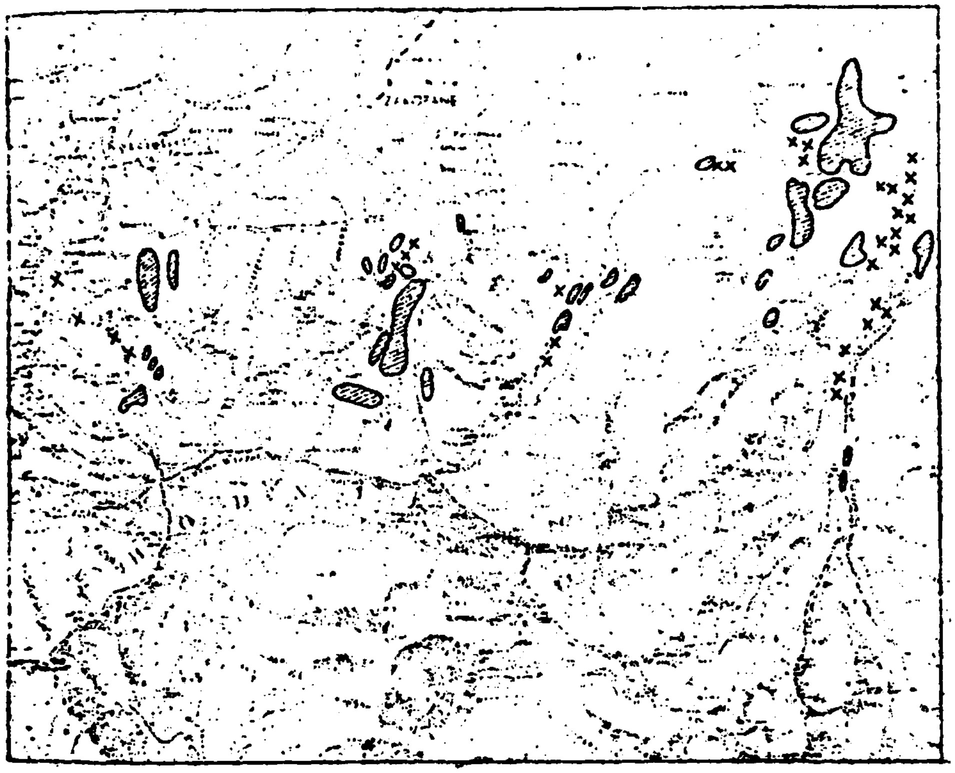

Figure 2. Areas of destruction caused on 6 May 1968
in the region of Tatra National Park

of Kroscienko. The timber damages in Beskid Zywiecki are concentrated mainly in the upper part of river Sola.

One can observe both falls and breaks of trees in the areas which suffered destruction. Falls are seen in the case of weakly-rooted trees or trees growing in wet soil; such trees are torn out with their roots (Photograph 2). In the case of breaks, the trunks only were broken, since the roots - better spread out in a dry and somewhat thicker layer of soil - resisted the action of strong winds (Photograph 3). These breaks occurred at different

Photograph 1. Wind-broken trees in lower Kalatowki

heights, beginning at about 1 m, up to more than ten meters above the ground level (Photograph 4). A large number of trees bent under the pressure of wind and remained inclined to the ground.

The directions of fall of trees are in general between 230° and 250°, reaching sporadically 180° and 270°, which corresponds approximately to the direction of winds recorded at that time in the area of Southern Poland. Moreover, in some places one could

Photograph 2. Trees torn out by wind at Zlatna

Photograph 3. Trees wind-broken at Kuznice and Kalatowki

Photograph 4. Wind-broken trees at Wantule

see trees which were torn out with their roots and thrown - as if by the force of explosion - in opposite directions. This fact would evidence a very strong turbulence which accompanied the winds. An illustration of this feature is provided by the distribution of directions of tree falls near and in the area of Wantule forest (Photograph 4). The destructive air stream arrived at Wantule at the distance of about 200 m from the edge of forest at Hala Mietusia along the slope of Gladki Uplazianski, breaking and tearing out trees. From the direction of falling of these trees it follows that the direction of movement of this stream was, in this case, Western. The air stream hit Wantule for the second time from the North, making the remaining trees fall at a nearly straight angle to the direction of fall of trees wich were uprooted earlier, and penetrating with a band 40-60 m wide in the depth of the forest above the first hit from the West. The power (and by the same token the velocity) of this stream can be judged from the fact that trees with diameters

of 60 cm and higher have been uprooted or broken.

This exceptionally strong wind of foehn character caused, in addition to uprooting and breaking trees, also damage to their foliage: in Regle region and in upper Zakopane one could encounter trees and bushes with dried out early spring leaves. This fact could be explained probably by an exceptionally strong evaporation--transpiration during the halny wind because of very low air humidity. It appears that the loss of water from the leaves was then considerably faster than the possibility of the intake of water by leaves from the soil. This situation, lasting probably for at least several hours, resulted in withering, drying and falling of needles from larch-trees and of leaves of other types of trees.

In addition to timbered areas in Tatras, some forests and buildings were destroyed in many locations of the High Beskids. According to concordant reports of meteorological observers and workers of forestry service the highest intensity of the wind in mountain regions on 6 May 1968 occurred between 18 and 21 hrs GMT.

2.1. The analysis of atmospheric conditions in the period of occurrence of the above mentioned strong winds was based on weather data from synoptic stations at Kasprowy Wierch, Zakopane and Aleksandrowice (Figures 3a, b, c). Information on periodic changes of air temperature and the direction and velocity of wind was also obtained from climatological posts in Antalowka, Lysa Polana, Kuznice, Hala Ornak, Myslenickie Turnie, Morskie Oko and Hala Gasienicowa (Figure 4a). Weather conditions in the area of Beskids are represented by stations: Miedzybrodzie, Zywiec, Zawoja, Zwardon, Kubalonka, Skrzyczne, Turbacz, Szczawnica, Przechyba and Stary Sacz (Figure 4b). Since the stations and climatological posts are performing observations only three times per day (at 7, 13 and 21 hrs local time), periodic changes of

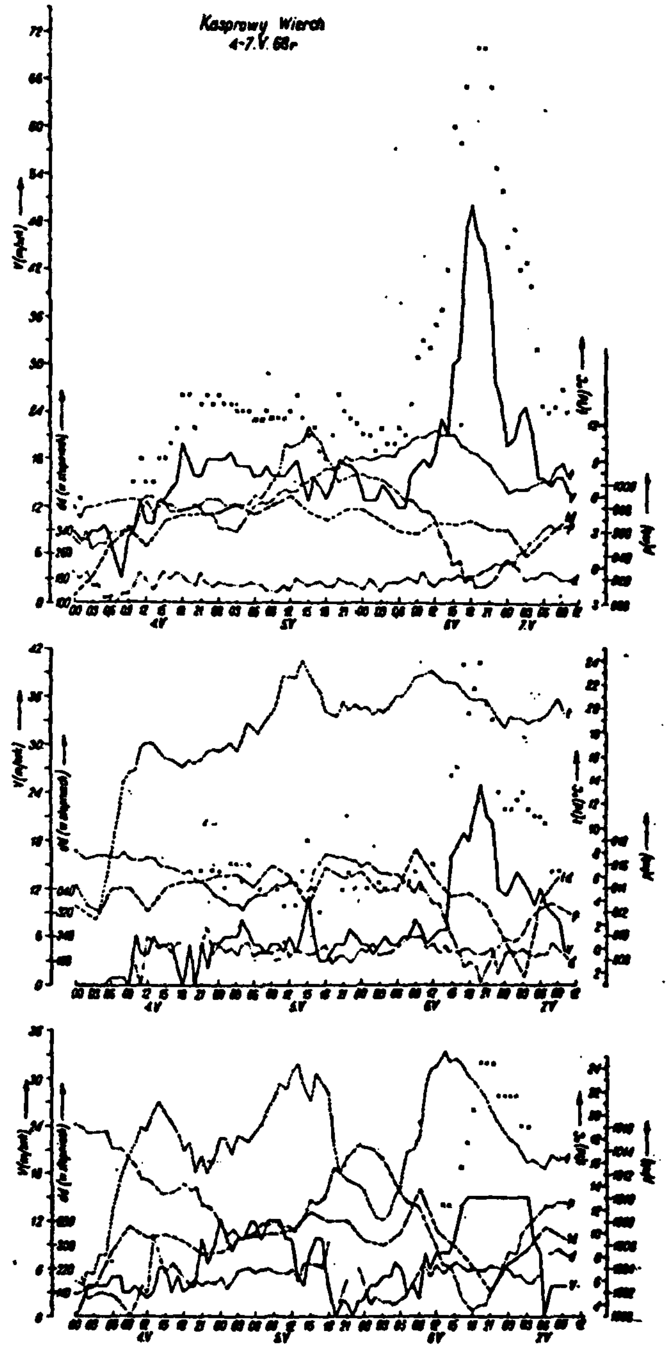

Figure 3. Weather calendar from the period 4 May 1968 0:00 hrs to 7 May 1968 9:00 hrs GMT

v - average wind velocity (m/sec); x - velocity of wind (m/sec) in gusts; d - wind direction; t - air temperature; t_d - temperature of the wind rose point; p - atmospheric pressure (mb).

a - Kasprowy Wierch, b - Zakopane, c - Aleksandrowice

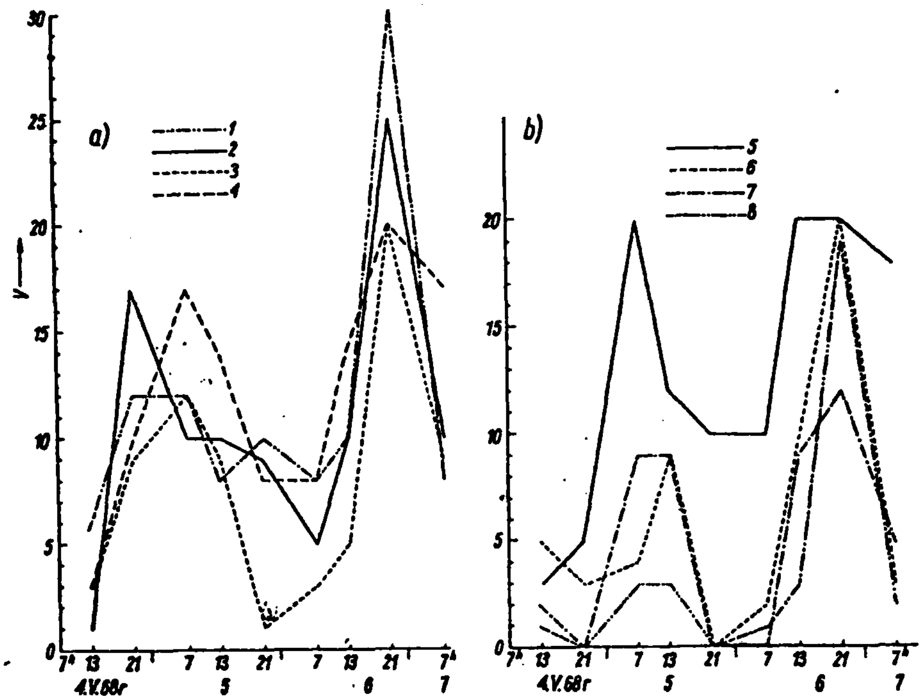

Figure 4. Time distribution of wind velocity in the period from 4 May 1968 11:40 hrs to 7 May 1968 11:40 hrs GMT

a) Tatra stations: 1 - Hala Gasienicowa, 2 - Myslenickie Turnie, 3 - Kuznica, 4 - Antalowka

b) Beskid stations: 5 - Skrzyczne, 6 - Kubalonka, 7 - Miedzybrodzie, 8 - Zywiec

meteorological elements, based on the data from these stations, should be treated only as supplements of the results of observations of the relatively rare network of synoptic stations.

In the discussed period of time the wind, both in Tatras and in Beskids, came from the 140°-260° directions. At Kasprowy Wierch a sudden jump in the average wind velocities occurred on 6 May between 14 and 22 hours GMT. The average wind velocities of wind at 18 hr GMT reached 50 m/sec; the velocity of wind gusts

at Kasprowy Wierch has been estimated to be about 75 m/sec. On the other hand, in Zakopane the sudden change of wind velocity took place on 6 May between hours 14 and 21 GMT; the average maximal velocity 25 m/sec (and in gusts ca 40 m/sec) was reached by the wind at 20 hrs GMT. At other stations of Tatras and Beskids the maximum velocity of wind occurred also on 6 May at ca 20 hrs of official time. The wind directions at that time were everywhere Southern and Southwestern, with exception of Morskie Oko where local deviations of direction should be explained by orography of the terrain.

The air temperature at Kasprowy Wierch and in Zakopane on 5 and 6 May shows a daily course different from its normal daily course for these locations. On 5 May the secondary minimum of temperature occurred between the hours 19 and 20 GMT. In later hours, despite rather small clouding (1/8 - 2/8) by high clouds Ci spi, there was an increase of temperature, accompanied by an increase in wind velocity, in Zakopane. On 6 May, in the period of the highest wind velocity, the air temperature ceased to fall. On 5 and 6 May the air temperature exceeded 23°C, approaching the maximum absolute value for this location.

At that time the relative humidity of air at Kasprowy Wierch varied in the range 60-90%. In Zakopane it was below 50%, and in the period of the highest wind velocity - merely about 40%. The minimum of this humidity (23%)occurred on 7 May at 03:00 hrs GMT.

Up to 23 hrs GMT on 5 May clouds at all ceilings were observed at Kasprowy Wierch. On 6 May in the hours 0 to 9 GMT there was absence of clouds at low ceiling. Nearly all this time the clouds Ac len were hanging over the Tatras. The presence of Cu clouds should also be noted; that presence would indicate the existence of entering air streams.

In Zakopane the clouding was usually rather small. Periodically clouds at all ceilings were observed. On 6 May between the hours 19 and 20 GMT, i.e. in a period of maximum wind velocity,

the covering of the sky by Cu con clouds decreased from 5/8 to 1/8, which evidences the intensity of falling (descending) movements, which caused "drying" of the air. This small sky coverage persisted through the whole night, and only at 9 hr GMT on 7 May the coverage increased to 6/8.

Differences in progress of weather situation on 6 May and on preceding day are shown on weather calendars (Figure 3) and by time analysis of changes in wind velocity. On 5 May at the majority of meteorological stations both in Tatras and in High Beskids the maximum wind velocities occurred in the daytime. Reduction of wind velocity between the hours 17 and 20 GMT was accompanied by a drop of air temperature and an increase of its relative humidity. In evening hours, about 23 hour GMT, a secondary maximum of air velocity with simultaneous increase of air temperature was observed in Zakopane and at Kasprowy Wierch. On 6 May in the afternoon and evening hours the wind velocity was increasing at all meteorological stations mentioned in this work, reaching average velocities above 20 m/sec*, i.e., at least twice as high as on the preceding day. At that time the air temperature in Zakopane decreased at first by merely 2^{o} but later, in the period of decrease of wind velocity, began to fall much faster. The secondary maximum of wind velocity occurred much later that night, at 3 hrs GMT. Simultaneously there was an increase of air temperature and drop of relative humidity to its minimum value.

2.2. The appearance of halny wind already in afternoon hours on 4 May was caused by the difference of pressures between the developed wedge of high pressure over Eastern and Southeastern Europe and the low pressure over England and Western Europe (Figures 5 and 6). These systems formed a blockade reaching to

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* Climatological posts are usually equipped with the Wild anemometers which determine wind velocities to 20 m/sec only.

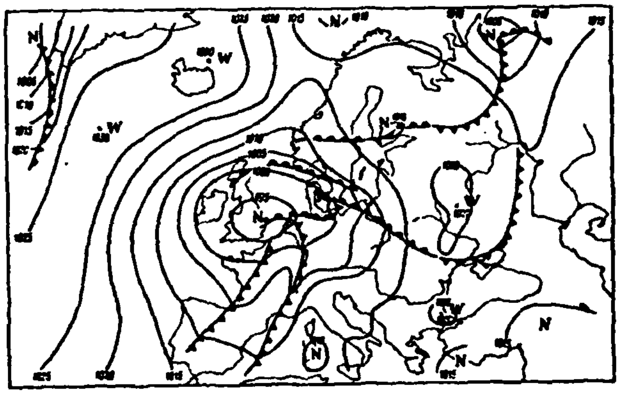


Figure 5. Synoptic map (low) for 5 May 1968 at 0:00 hr GMT

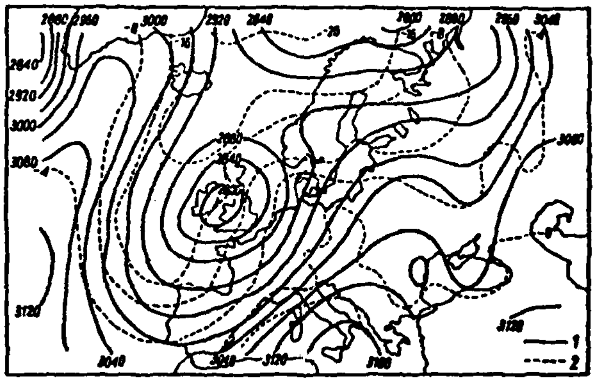


Figure 6. Map of isobaric surface 700 mb on 5 May 1968
at 0:00 hr GMT

Continuous lines - isohipses
Broken lines - isotherms
W = wysoki = High
N = niski = Low

the upper troposphere, and having nearly a vertical axis. During the next days the low pressure center became deeper in both the low and medium troposphere, and spread its influence on Central Europe (Figures 7 and 8). A warm front connected with this low pressure system crossed Carpathians; as a result, the Southern

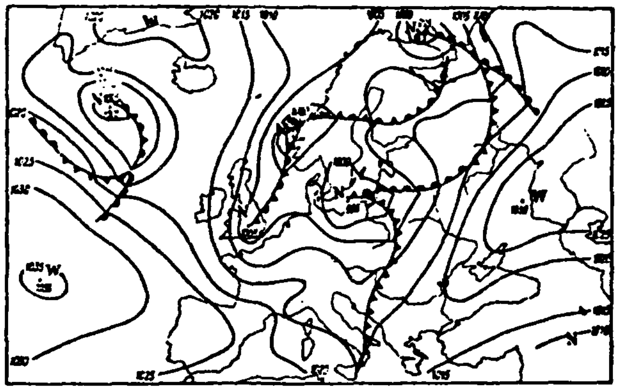


Figure 7. Synoptic map (low) for 6 May 1968 at 12:00 GMT

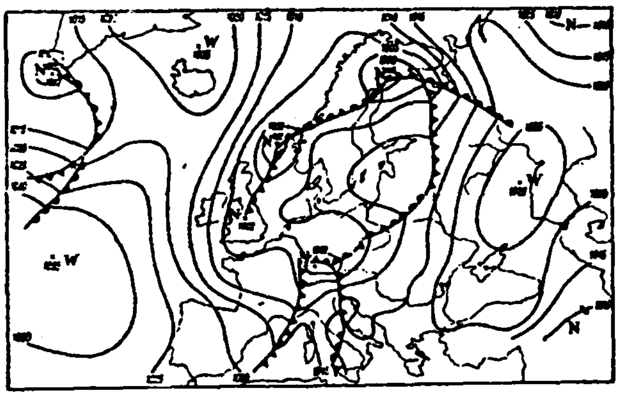


Figure 8. Synoptic map (low) for 7 May 1968 at 0:00 hr GMT

part of Poland found itself in a warm sector. It is worth noting that isobaric surfaces 850 and 700 mb show a warm area [51] located North of the Middle Alps.

On 6 May at 0:00 hr GMT the maps of low and isobaric surface 850 mb show two new secondary low pressure centers: one of them located over the North Sea and the second - important in our case - located over the West Alps. The latter in its initial stage reached merely the height 850 mb and had its axis strongly inclined to Northeast. In its further development it reached

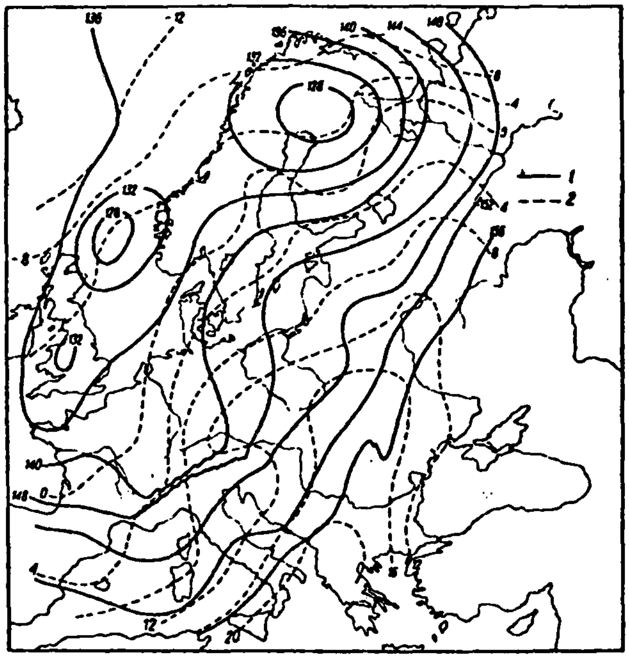


Figure 9. Map of isobaric surface 850 mb on 6 May 1968 at 12 GMT
Legend - as Figure 6

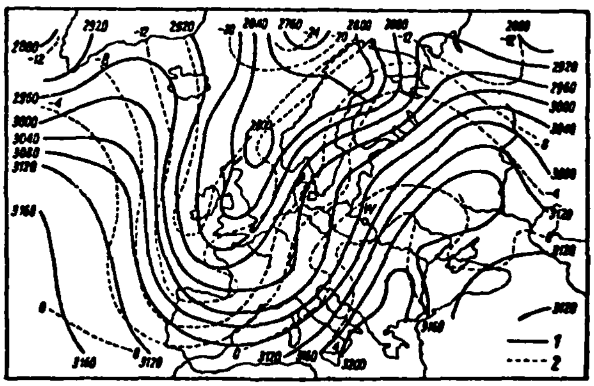


Figure 10. Map of isobaric surface 700 mb on 6 May 1968
at 12:00 hrs GMT

Legend - as Figure 6

the height 700 mb within the next twelve hours, moving to the North-east with a velocity of about 20 km/hour (Figures 9 and 10). During the next twelve hours, this low pressure center became more active and deeper and, thanks to further vertical buildup, it reached the middle troposphere. At this stage of its development it moved in the direction of pressure gradients on isobaric /53 surfaces 500 mb from Northern Germany to the Southern Baltic Sea with a velocity of 80-90 km/hour (Figures 11 and 12). It was at the time this secondary low pressure center moved over Northwestern Poland that these unusually strong winds occurred in the Carpathians.

In the considered period of time a stream of air developed in the upper troposphere. Its two cores ran over Western Europe from the Southwest to Northeast; one of them moved over the North Sea, Scandinavia and Finland, and the other - over Western and Central Europe and Central Russia. In the period of the highest intensity of winds over the area of the West Carpathians the height of the more Southern core of air stream, running above Central Poland, reached its minimum, descending as low as 250 mb on 5 May at 0 hr GMT to about 350 mb on 7 May at 0 hr GMT. At the same time, this part of the stream reduced its velocity (Figures 13 and 14).

In the period from 4 to 7 May, the wedge of warm air reaching the upper troposphere had practically no change of position over /54 Southeastern Europe. During all this time, warm air from the Southwest was flowing over the area of Central and Southeastern Europe. The highest temperatures were reached on 6 May in the afternnon hours.

2.3. The analysis of low maps shows that on 6 May the above mentioned secondary low pressure center was moving from Southern Germany through West Pomorze to the Baltic. Between 51 and 53^{o} Northern geographical latitude, there was a warm front, running

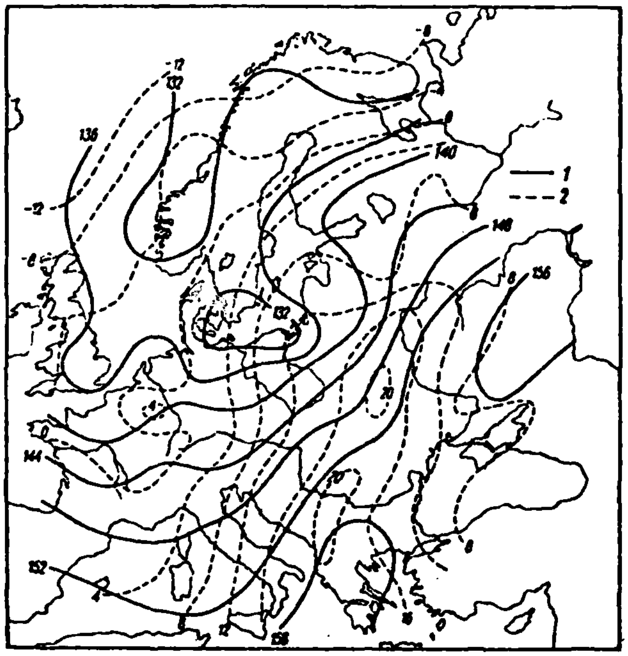


Figure 11. Map of isobaric surface 850 mb on 7 May at 0 hr GMT
Legend - as Figure 6

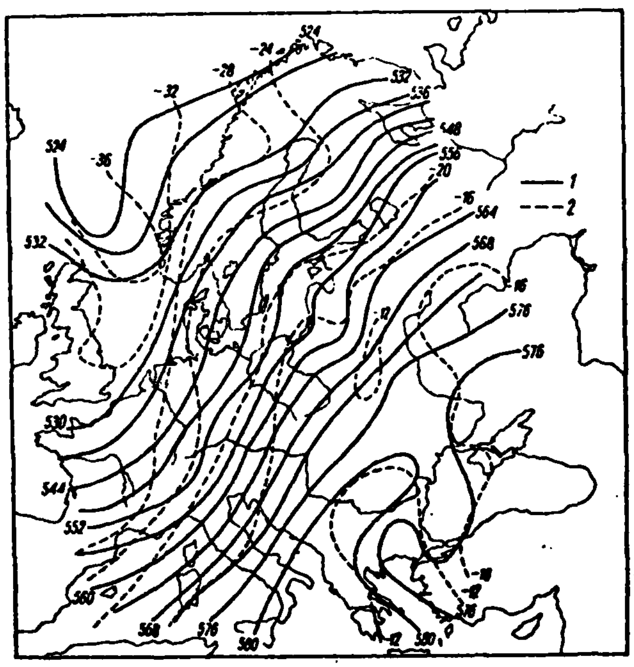


Figure 12. Map of isobaric surface 500 mb on 7 May at 0 hr GMT
Legend - as Figure 6

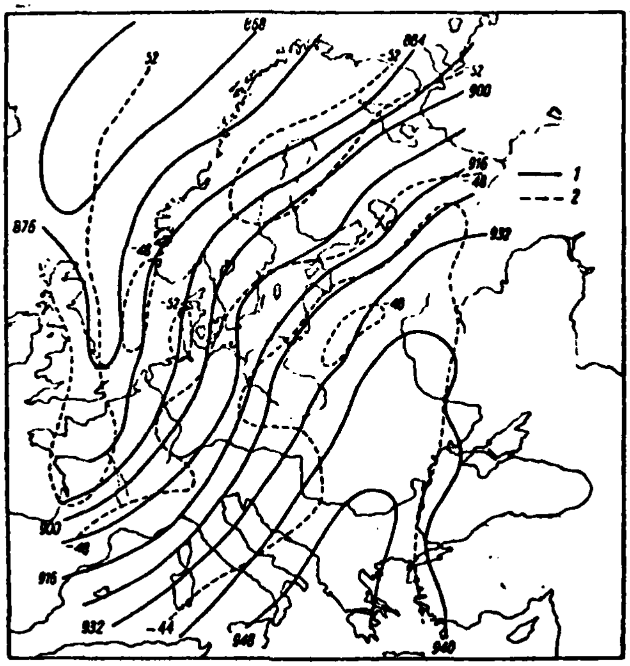


Figure 13. Map of isobaric surface 300 mb on 7 May at 0 hr GMT
Legend - as Fig. 6.

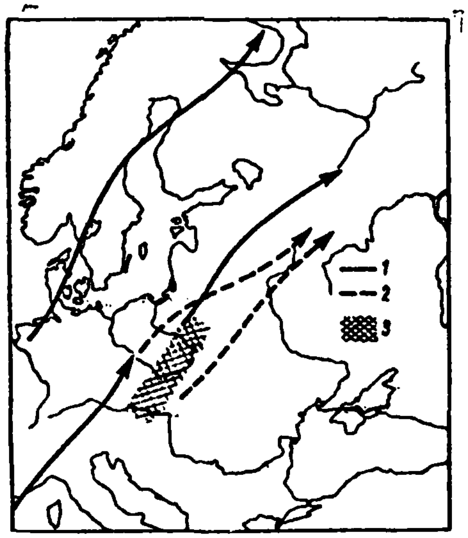


Figure 14. Location of axis of stream currents on 7 May 1968 at 0 hr GMT

1 - uppertroposheric stream current at the level of about 340 mb
2 - lowertropospheric stream current at the level of about 760 mb
3 - area of descending movements

along parallel in latitude and moving Northwards very slowly. Air temperatures in the warm sector over Southern Poland in afternoon hours varied in the range 24-29 ^{o}C, and they were by about 6-9 ^{o}C lower in the cooler mass of air.

As we mentioned above, the warm sector visible on low maps reached the boundary of the troposphere (cf. Figure 11-13). The cold front, also clearly shown in lower and middle troposphere, was at 18 hr GMT on the line of Odra river and moved to the East. Its velocity was initially about 70 km/hour, but after 21 hr GMT it was reduced to 30 km/hour. The movement of this front caused simultaneously a somewhat faster movement of the warm front.

Already at 19 hr GMT there is a clear indication of the presence of "halny front" at Pogorze and Wyzyna Slaska. It is shown by convergence of winds and lower values of the temperature of rose point in the mass of air located behind it. The front line up to 23 hr GMT moved to the North with a velocity of about 60-70 km/hour, showing higher velocities in its Western part than in its Eastern part (Figure 15).

3. An analysis of space distribution of atmospheric pressure and air temperature in the period 4-7 May, and particularly in the hours 18-24 GMT on 6 May, allows us to state that winds of high velocity were caused by simultaneous action of three factors, namely:

a) a specific distribution of pressure, which caused the appearance of halny winds already on 4 May
b) an increase of pressure gradient in the evening of 6 May,
c) effect of the barrier of mountains.

As we already pointed out in Section 2.2, the increase of gradient resulted from deepening of the secondary low pressure system initially in ground-adjacent layers,and then - as the synoptic situation developed - also in the lower and middle troposphere. This system moved at the edge of a high blockade

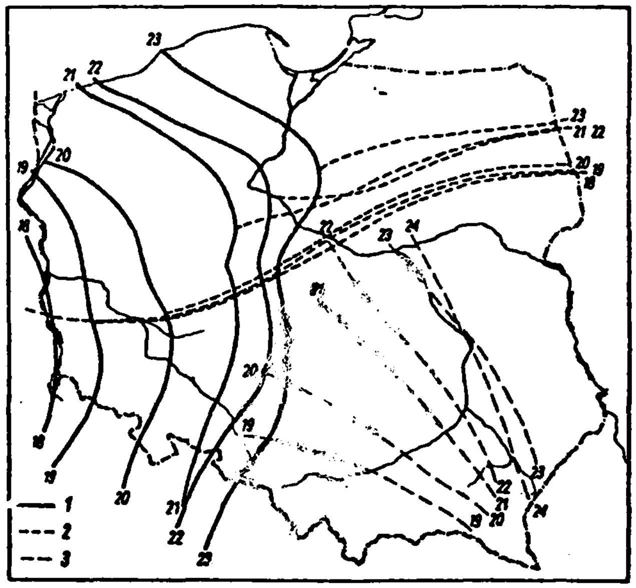


Figure 15. Location of the lines of fronts on the area of Poland on 6 May 1968 between hours 18-23 GMT
1 - cold front; 2 - warm front; 3 - "halny front"

over the Northeastern Europe following the main direction of runoff on isobaric surface 500 mb. The high pressure system was built up to the upper boundary of troposphere; therefore the developing secondary low system could not move it to the East and only caused an increase in pressure gradient in the lower troposphere at the edge of the high system. This is illustrated by isotachs on isobaric surfaces 850 and 700 mb, which reveal the presence of branched stream of strong winds (Figure 16). This stream is joined through the troposphere with Southern branch of the upper troposphere stream current (Figure 17), whose core was considerably lower on that day. Velocities of the upper stream current underwent considerable reduction in this area (in comparison with the previous day). One can assume, therefore, that part of this energy was transferred to the lower tropospheric

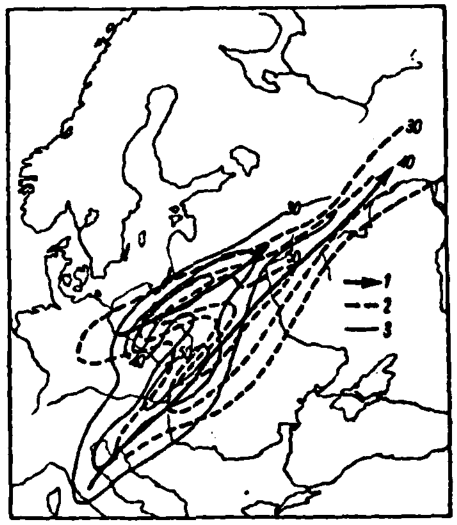


Figure 16. Map of isotachs of isobaric surfaces 850 and 700 mb on 7 May 1968 at 0 hr GMT

1 - axis of stream current; 2 - isotachs on surface 850 mb; 3 - isotachs on surface 700 mb (isotachs are drawn every 10 knots)

current. This assumption is strengthened by the presence here of vertical movements downwards (cf. Figure 14).

Two branches of this low stream current can be distinguished on maps of isobaric surfaces 850 and 700 mb on 7 May at 0 hr GMT, Figure 16. The shorter Northern branch is connected directly with the above discussed very active secondary low system, which at this time is placed over the Southern Baltic. It lies over Northern part of Poland, over the lowlands, hence it does not cause any striking consequences. On the other hand, the second branch, which was observed at the height of 2000-2500 m above Carpathians, caused havoc in the mountain areas. As is seen in Figure 16, this branch starts over Carpathians and ends by joining the Northern branch over Central Russia. The appearance of the Northern branch appears to be due only to an increase of pressure gradient.

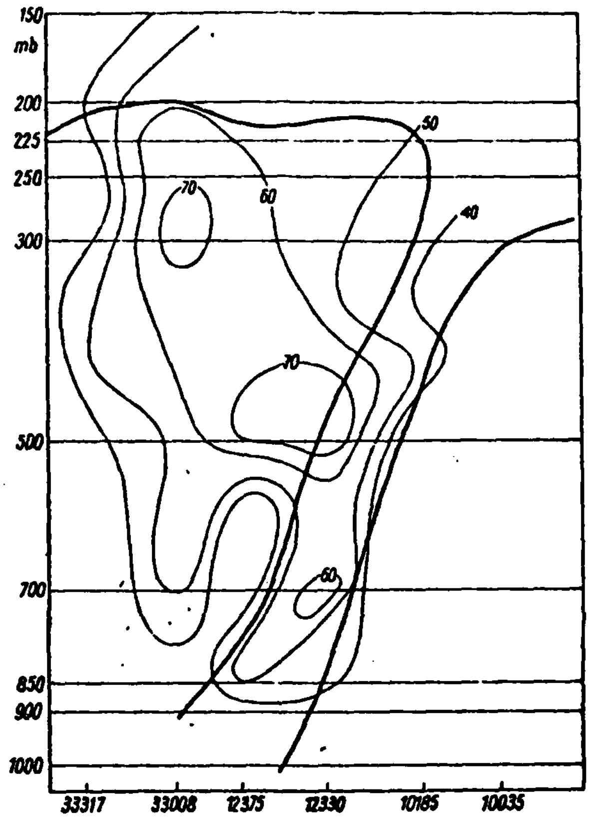


Figure 17a. Vertical cross-section through the troposphere on 7 May 1968 at 0 hr GMT

1 - tropopause and frontal surface;
2 - isotherms; 3 - isotachs

But the appearance of the Southern branch, which is certainly at some distance from the mentioned active low pressure system, must /58 have been caused, undoubtedly, by orographic conditions on the surface of the earth.

In the period of May analyzed here, the existence was noted twice of these low streams in the lower troposphere. They had high velocities (ca 15-20 m/sec). Their width was ca 200-300 km, length - 1500-2000 km, and thickness - about 1 km, and the remained for 24 to 36 hours moving together with the secondary

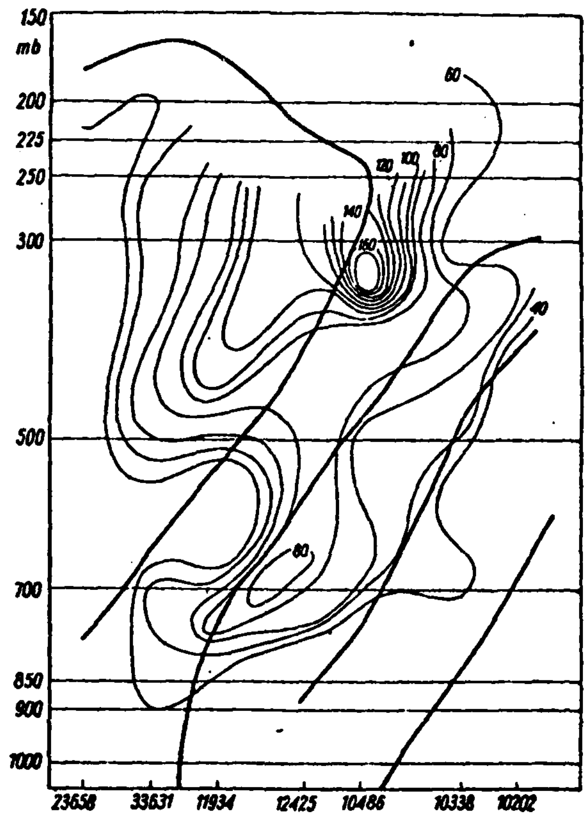
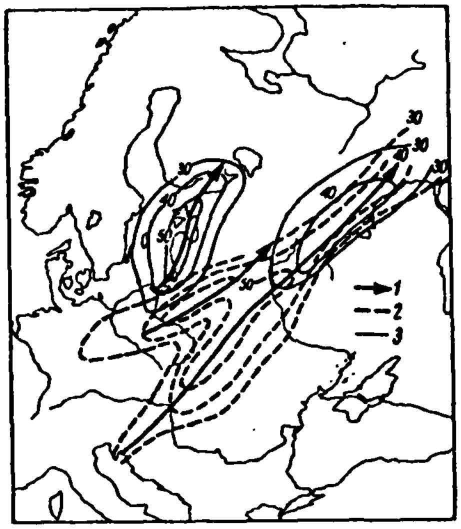


Figure 17b. Vertical cross-section through troposphere on 7 May 1968 at 0 hr GMT

Legend - as Figure 17a

system of low pressure, and joining the stream current of upper troposphere - Figures 18 and 19. They appeared during the formation of secondary, very active low pressure systems at the edge of a strong blocking system of high pressure.

These highly developed zones of strong winds appearing, as far as the day 6 May is concerned, already on the surface of the Earth, are connected with zones of a large horizontal temperature gradient, reaching from the Earth's surface up to the tropopause.



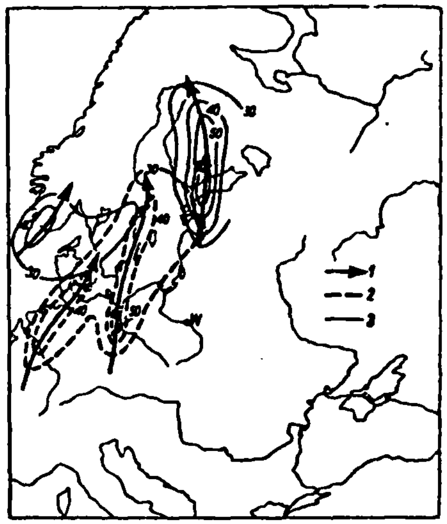


Figure 18 (left). Map of isotachs on surface 850 mb on 7 May 1968 at 0 hr and 12 hr GMT Legend - 1 - axes of low-tropospherc stream current; 2 - isotachs at 0 hr; 3 - isotachs at 12 hr

Figure 19 (right). Map of isotachs on surface 850 mb on 5 May 1968 at 12 hr GMT and on 6 May at 0 hr GMT Legend - 1 - axis of stream current; 2 - isotachs on 6 May; 3 - isotachs on 5 May

The air temperatures in the period of maximum air velocities (see Figures 3a, b, c and 20) are high because of advection of air masses, which are warm for this season of the year, and of the halny wind which stayed for over 48 hours. These temperatures are about 20°C in Zakopane and 15°C at Myslenickie Turnie, and they decrease slowly with an increase of height, not causing, however, the appearance of inversion. Similarly, turbulence does not disappear despite the night hours; wind blasts reaching 40 m/sec were noted in Zakopane in the period of the maximum average wind velocities. Hence, even because of this strong turbulence and absence of inversion of air temperature, this stream of strong winds at the level 700 mb cannot be identified with the phenomenon known in the

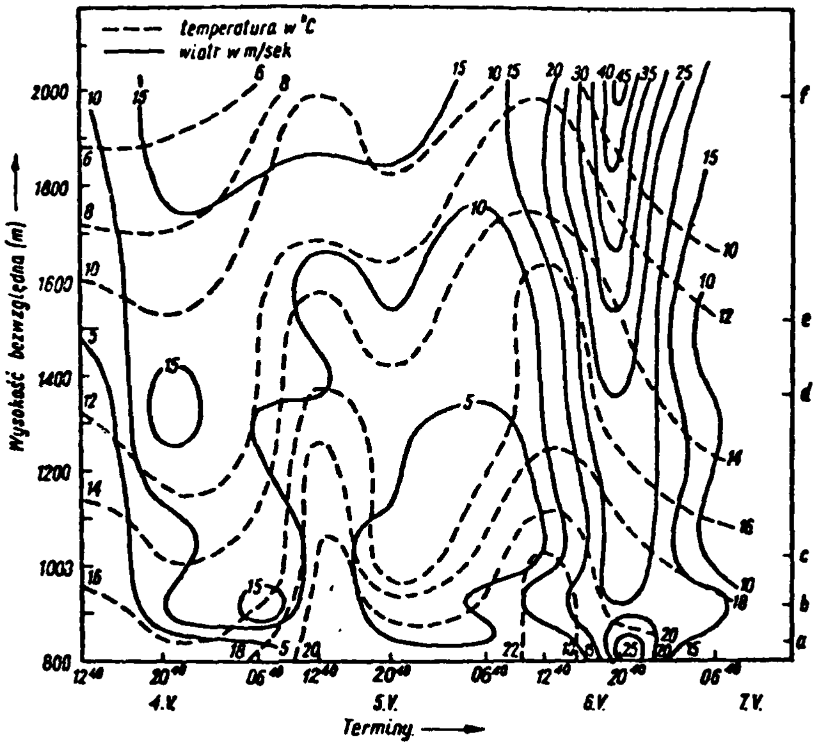


Figure 20. Isoplets of wind velocity and air temperature in the section Kasprowy Wierch - Zakopane from 4 May 1968 11:40 hr to 7 May 5:40 hr GMT

Ordinate - Absolute height (m)
Abscissa - Date and time
Continuous lines - wind velocity in m/sec
Broken lines - air temperature in °C

literature under the name low-level jet [1, 8]. Neither can it be identified with the stream wind in the sense proposed by J. Kalicki [2]. It appears that it should be considered as low-troposphere jet streams.

Figure 20 shows isoplets of air temperature and wind velocity in the period of time from 4 May 20 hr GMT to 7 May 3 hr GMT for stations lying along the line Kasprowy Wierch - Zakopane (the data from those stations were utilized in absence of aerologic measurements, assuming that values of air temperature and wind velocity in free atmosphere in the discussed period of

time and region are close to the results of observations at the above mentioned stations [3]). It follows from this Figure that the vertical distributions of wind velocity on the nights 4/5 May and 6/7 May are similar, but the distribution of these velocities in the night from 5 to 6 May differs greatly from them. On that night there was a reduction of wind velocity with an increase of height to about 150 m above the valley bottom, whereas in the preceding and following nights the air velocities increased with increase of height in the evening and night hours. Also, vertical distributions of temperature in the nights from 4 to 5 May and from 6 to 7 May were similar. There was no inversion of temperature in the night during halny winds, but it took place in the period reduced wind velocity. In the night from 4 to 5 May, just as in the night from 6 to 7 May, thermal conditions existed favoring the appearance of strong winds, but the second factor did not exist - a sufficiently large pressure gradient. It is possible that the presence of inversion and reduction of the wind velocity with an increase of height in the night from 5 to 6 May was connected with settling of air in ground-adjacent layers in the area covered by the wedge of high pressure. This settling would cause a reduction of relative humidity of air to about 30%, which is seen on the map of the isobaric surface at 850 mb and in vertical cross-sections.

We can assume that the main reason for such high wind velocities at the Earth's surface was stream currents at the level of ca 760 mb. A vertical cross-section through this stream over the region of the Carpathians on 7 May at 0 hr GMT shows clearly, below the stream current of the upper troposphere at the height of about 340 mb, a second - considerably weaker - maximum of wind velocities at the height of about 760 mb (see Figure 17). Measurements show that wind velocity at that height in the free atmosphere over Poprad (station 11 934) was 38 m/sec. Of similar magnitude were also velocities measured at Kasprowy Wierch at the time

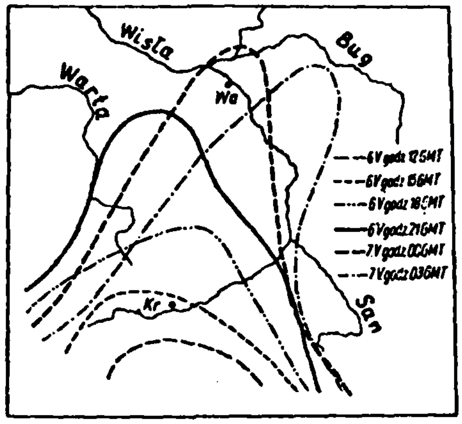


Figure 21. The range of effects of halny wind in the period from 6 May 1968 12 hr to 7 May 1968 3 hr GMT
Wa = Warsaw; Kr = Cracow

of maximum wind intensity (about 50 m/sec). The wind directions are also in agreement (about 240° in the core current, both over Poprad and Kasprowy Wierch), despite the fact that one could expect to have some deviations from the direction in free atmosphere on account of orographic effects of Tatras [6, 7] .

4. As was mentioned already in Section 2.3, the air blowing on Northern slopes of Tatras was moving to the North. Its range is marked by the "halny front", talked about in Section 2.3. In order to define more precisely its range we shall analyze below the distribution of temperatures of rose point, treating it as a constant characteristic of the mass of air in the course of its horizontal transport. Figure 3 shows that the maximal value of the temperature of rose point in the period of halny winds was 8.2 $^{\circ}$C in Zakopane. Looking for similar values of t_d at other synoptic stations (and we assumed 9.0 $^{\circ}$C as the limiting value) we drew on the map the course of isodrosotherms for 9.0 $^{\circ}$C, treating this isoline as a boundary of "halny air". Isodrosotherm is a line joining points with the same values of the temperature of rose point. As is seen from

Figure 21, the range of influence of this air, which on 6 May at 12 hr GMT (i.e., after 48 hours of the halny wind staying at Zakopane) extended only a little beyond Podhale, twelve hours later reached the latitude of Plock. An approximate range of influence of halny wind has been found previously [5, 9]. As shown by the results of observations by the stations, performed every three hours, the isodrosotherm of 9.0°C moved initially as a broad belt with a velocity of about 30 km/hour. Beginning at 18 hr, this belt became narrower (to about 150 km) and its velocity increased to 60-70 km/hour.

The displacement of dry "halny air" from the South to the North was in agreement with the general direction of wind movement in the ground-adjacent layer, but it was not in agreement with the direction of movement in the lower troposphere (850-700 mb), where the air moved from Southwest to Northeast (i.e., following the direction of winds in the Tatras in the period of their maximal velocities). As far as the deplacement velocity of this "halny air" is concerned, this velocity was clearly dependent on the velocity of air in the lower troposphere, and increased in the period of its maximal value.

In the hours 21-24 GMT, on 6 May, the line of "halny air" was displaced not only to the North but also to the East, and then in the next three hours - only to the East. This behavior was caused by fast movement of the cold front from the West to the East, which resulted in pushing "halny air" ahead of it. As a consequence, we had a change of weather in the mountains, cessation of strong halny winds, and dryness of the air.

5. It follows from the above that:

a) large wind velocities over Tatras were caused in the considered case by the appearance of streams of strong winds at the height 2000-2500 m;

b) these streams, called by the authors the "low-troposphere jet streams" , appeared in the region of mountain barriers during the system of pressures characteristic for halny winds in the area of the Carpathians;

c) it was found that the mentioned low-troposphere jet stream is formed in different thermobaric conditions than the low-level jet;

d) the development of conditions in the analyzed case was caused partly by stability of large-scale pressure systems; it appears that the major role in the appearance of this type of dangerous phenomena is played by strong, high developed blockades of high pressure, slowing down the movement of secondary baric systems and causing thereby the formation of large gradients of pressure and temperature;

e) it follows from an analysis of the discussed case that the effects of halny winds may reach as far as the Warsaw Basin.

In closing, we wish to fulfill the honored and pleasant duty of expressing our thanks this way to Doc. S. Rafalowski, assistant director for prognosis at PIHM, for assistance given in the course of preparation of this work; to Prof. Dr. T. Kopcewicz for many critical but very valuable for us remarks; and to Prof. Dr. M. Orlicz for making accessible observational materials.

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SUMMARY

Foehns, called locally wiatry halne, are not a rare occurrence in the Carpathian Mts., where they cause every year more or less extensive destruction on timbered areas. The damages produced by the foehn of May 6, 1968 in the Tatra Mts., on Podhale and the High Beskids were however exceptionally great: according to preliminary estimates were destroyed on this day about 360 000 cu m of timber on the Polish side and about 100 000 cu m on Slovak territory (conf. plates 1–4).

A detailed synoptic analysis has shown that the high wind velocities over the Tatra Mts. were in this case due to powerful wind streams at 2000–2500 m altitude, called by the present writers "low-troposphere jet streams". They occurred in the area of the mountain barrier during a pressure system which in the Carpathian region is characteristic for the foehn wind. It was found that the mentioned low-tropospher jest stream foms under conditions differing from those of the low-level jet. To the development of the situation described here contributed the large-scale stability of the pressure systems. It would seem that the decisive role in the formation of dangerous phenomena of this type is plaid by high-pressure blockades built-up to great altitude which hamper the movements of secondary pressure systems and cause thereby the formation of high pressure and temperature gradients. The analysis of this case has also shown that the effects of foehn wind can reach as far as the Warsaw basin.

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